



1998 IEEE AP-S International Symposium and USNC/URSI National Radio Science Meeting

Atlanta, Georgia June 21-26, 1998
Renaissance Waverly Hotel

Final Call for Papers

The 1998 URSI National Radio Science Meeting, sponsored by the USNC/URSI, and the 1998 IEEE AP-S International Symposium sponsored by the IEEE Antennas and Propagation Society (AP-S), will be held jointly at the Renaissance Waverly Hotel in Atlanta, Georgia, 21-26 June 1998. The technical sessions, workshops, and short courses will be coordinated among the two symposia to provide a comprehensive and **well-balanced program**.

★ Electronic Paper Submission ★

The 1998 IEEE AP-S/URSI Symposium in Atlanta will mark the first use of electronic paper submission by the USNC and the AP-S Society. In addition, the conference digests will be placed on an archival CD-ROM with a fully indexed and searchable system for **fast** document retrieval. For the first time in the history of this conference, authors will be able to submit their work with full color illustrations and figures and attendees will be able to search the CD based on topic keyword and author name! Authors should visit the Symposium homepage and the Technical program Committee (TPC) web page for detailed information on how to take full advantage of available technology when submitting a paper.

To guard against the hazards of the electronic age and electronic submission, all summaries and abstracts must also be submitted in paper form by 19 January 1998 to Wilson Pearson's address listed herein. The paper copy will be used for backup purposes in the event that an author's electronic copy is unusable.

Detailed Information. To assist authors in the preparation and submission of the electronic copy of their summary or abstract, several information sources will be available. Information may be obtained from the Technical Program Committee web site: <http://apsursi98tpc.ces.clemson.edu>. Information may be obtained via FTP by downloading an Adobe Acrobat file (submission.pdf) or a text file (submission.txt) from apsursi98tpc.ces.clemson.edu. Finally, one may send e-mail with the subject SUBMISSION to apsursi98tpc.info@ces.clemson.edu to generate an automatic reply message containing full details on preparation and submission.

For those who cannot comply. It is expected that a very small number of authors will be unable to generate an electronic copy of the summary or abstract. These authors must submit one original and three copies of their contribution, along with the completed copyright form, to Wilson Pearson at the address given by 5 January 1998.

Interactive Forum

An Interactive Forum will be held daily during the first three days of the Symposium and Meeting. The space provided for forum presentations will include approximately forty square feet of tackboard space, a table, and access to electrical power if needed. The forum will be located in an open central public area of the meeting. Consequently, the interactive forum vehicle provides an alternative to

ELECTRONIC FILE SUBMISSION PROCESS

For e-mail submission, you may embed either a Postscript, **MIME** encoded, or UU encoded file as text in a transmittal message
or
you may attach a file to an e-mail message using recent versions of Eudora or Pegasus. **PKZipping** of large files is acceptable.

Acceptable File Formats

- *.pdf (Adobe Acrobat)
- *.ps (level 2 Postscript)
- *.doc (Word for Windows)
- *.wpd (WordPerfect for Windows)

Methods of Submission

- FTP (preferred)
- e-mail (internet)
- mail floppy disk
- mail paper copy (only)

Notification

Authors who use FTP, mail a floppy disk, or mail a paper copy must send a **notification e-mail** to apsursi98tpc.info@ces.clemson.edu (See the TPC Web site for a suggested format)

All content must be embedded in a **single file** for submission

podium presentations that lends itself to better exposition of many results. For example, the large display area provides the means for comparative display of a large number of charts for results-intensive presentations. The table and power provide the means for interactive computer presentations. Authors are encouraged to take advantage of this format in a creative fashion. The best use of the Interactive Forum will be recognized at the Awards Banquet. **Authors are asked to designate their desire to participate in an interactive forum at the time they submit their papers.**

Instructions for all Authors

The e-mail or letter accompanying the summary (for **AP-S**) or abstract (for **USRI**) **must indicate a topic number** associated with AP-S or USRI from the tabulation elsewhere in this Call. Papers submitted for the student paper competition should be so designated and comply with instructions below. It must contain the complete mailing address, telephone number, e-mail address, and fax number of the corresponding author. Where there are multiple authors, specify the presenter by an asterisk. Authors desiring placement in an interactive forum should indicate this in their transmittal. The presentation equipment needed (viewgraph, 35 mm slide projector, etc.) should be also be specified.

The language of the conference is English. Simultaneous interpretation **will not** be provided. The text should be formatted single spaced and sized for 21.5 x 28-cm (8.5 x 11 inch) paper. The title should be centered 1 inch from the top of the first page. The author's (or authors') name and complete organizational **affiliat** ion should be two lines below the title. The text should start three lines below the last name. Left and right-hand margins should be 4 cm (1.5 inches). A 2.5-cm (1-inch) margin should be at the top and bottom of all pages. Double space between paragraphs. Submissions must withstand a linear reduction to 70% of original size **and** maintain readability y. Only the corresponding author will receive an acknowledgement of the submission. **FAX SUBMISSIONS WILL NOT BE ACCEPTED.**

Additional Instructions for AP-S Authors

The summary must be limited to four pages including text, references, figures, and photographs. The introduction should indicate clearly how the submission relates to previous work and the unique aspects of the current submission. One paper copy and one **elec- tronic** copy (see Mow) of the summary must be submitted in final form. Figures and photographs (in glossy prints) should be a convenient size and affixed on 21.5 x 28-cm (8.5 x 11) white paper with captions typed in appropriate places. Footnotes should not be used except for credits to sponsoring agencies. A signed copyright form is necessary with submission of the paper copy (forms are in recent issues of the IEEE Transactions on Antennas & Propagation and available through the **homepage**). Missing copyright forms will make it necessary to reject the paper. It will be understood that all submissions have been cleared by the sponsoring agency.

Additional Instructions for USRI Authors

The abstract must consist of at least 250 words, and must be limited to one page, including figures. **One** paper copy and one electronic copies of the abstract must be submitted in final form. Do not include a list of references, a few open literature references may be included parenthetically, for example (R. L. Lewis and J. R. Johler, Radio Sci., 2, 75-81, 1976). Acknowledgement of financial support is not deemed appropriate.

Provide *an accompanying second page* that includes (1) identification of Commission and session topic for the paper (2) a statement of what new knowledge is contributed by this paper, and (3) the relationship of this work to previous work.

AP-S Student Paper Competition

A student paper contest for full-time students will be held as part of the symposium. To be considered, a student must be the first author of the paper. The student's advisor should attach a statement that **his/her** contribution is primarily advisory. In addition, e-mail notification (or transmittal letter) should clearly indicate student paper submission and conform to **all** other submission requirements as delineated above. Student papers judged as finalists will be presented at the conference **in the interactive** forum format.

Submission Addresses

Submit electronic form of documents via one of the following mechanisms:

FTP: [apsursi98tpc.ces.clemson.edu](ftp://apsursi98tpc.ces.clemson.edu)
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Submit paper copy and copyright form to
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Deadlines

For authors submitting **electronic** copy, the deadline for the receipt of it is 12 January 1998. The deadline for the corresponding **backup paper copy** is **19 January 1998**. For authors who cannot comply, the **paper-copy** deadline is **5 January 1998**. **All deadlines will be adhered to strictly.**

Web Addresses

<http://seal.gatech.edu/EEED/AP-URSI98/ap-ursi98.htm>
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(Symposium homepage)
(TPC Information homepage)

Authors are invited to submit papers of interest to the AP-S membership and to the following URSI commissions:

AP-S Special Sessions (These sessions will comprise, in part, invited speakers, but contributions are welcomed.)

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|------|--|------|---|
| AP-1 | Keynote Session: The Next Generation of Communications Satellites | AP-5 | Session Honoring Prof. T. B. A. Senior |
| AP-2 | Keynote Session: The Next Generation of Communications Satellites—Antennas, the Enabling Technology | AP-6 | Session Honoring Prof. R. E. Collin |
| AP-3 | Keynote Session: Wireless (Terrestrial) Networks | AP-7 | Equivalence Principle |
| AP-4 | Keynote Session: Measurements | AP-8 | Spatial Power Combining of mmW Radiation ← |

AP-S General Sessions

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|-------|--|-------|--|
| AP-9 | Adaptive, active, signal processing & imaging antennas | AP-24 | Microstrip antennas, arrays, and circuits |
| AP-10 | Biomedical Applications | AP-25 | Monolithic array techniques |
| AP-11 | Broadband and multifrequency antennas | AP-26 | Phased array antennas |
| AP-12 | Mobile and PCS antennas | AP-27 | Applications of Photonics in antenna systems |
| AP-13 | Electromagnetics Education | AP-28 | Digital beamforming |
| AP-14 | Electromagnetic properties of materials | AP-29 | Non-linear electromagnetic |
| AP-15 | Electromagnetic theory | AP-30 | Optimization methods in EM design |
| AP-16 | Frequency selective surfaces | AP-31 | Neural networks |
| AP-17 | FEM methods | AP-32 | Reflector antennas |
| AP-18 | FDTD methods | AP-33 | Scattering, diffraction and radar cross section |
| AP-19 | Wavelet-based methods | AP-34 | Radar imagery |
| AP-20 | Transients and time domain techniques | AP-35 | Propagation |
| AP-21 | Numerical methods | AP-36 | Random media and rough surfaces |
| AP-22 | Inverse scattering | AP-37 | Remote sensing |
| AP-23 | Waveguiding structures | AP-38 | Other topics |

COMMISSION A, Electromagnetic Metrology

- A-1 General

COMMISSION B, Fields and Waves

- | | | | |
|-----|---|------|---|
| B-1 | .. Novel Methods (Special Session) | B-9 | Numerical methods (differential equations) |
| B-2 | Antennas | B-10 | Numerical methods (integral equations) |
| B-3 | Arrays | B-n | Numerical techniques (hybrid and other) |
| B-4 | Complex media | B-12 | Rough surfaces and random media |
| B-5 | Guided waves | B-13 | Scattering |
| B-6 | High frequency techniques | B-14 | Theoretical electromagnetic |
| B-7 | inverse scattering | B-15 | Transient fields, effects, and systems |
| B-8 | Microstrip lines, antennas, and circuits | | |

COMMISSION D, Electronics and Photonics

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|-----|---|-----|--|
| D-1 | Microelectromechanical Systems, MEMS (Special Session) | D-5 | Microwave, millimeter wave, and submillimeter wave devices and circuits |
| D-2 | Optoelectronic techniques, devices, and materials | D-6 | High speed devices and circuits |
| D-3 | Cryogenic electronic devices and circuits | D-7 | Mesoscale devices and associated materials |
| D-4 | Optical transmission and interconnection | D-8 | Vacuum microelectronics |

COMMISSION F, Wave Propagation and Remote Sensing

- | | | | |
|-----|--|-----|--|
| F-1 | Terrestrial Propagation Effects (Model and Mess.) | F-3 | Indoor Propagation (Model and Measurements) |
| F-2 | Satellite-Earth Propagation (Model and Measurements) | F-4 | Mobile Propagation (Model and Measurements) |

COMMISSION K, Electromagnetic in Biology and Medicine

- | | | | |
|-----|---------------------------------|-----|--|
| K-1 | Electromagnetic in medicine | K-3 | Biological effects of wireless communication radiation |
| K-2 | Bioelectromagnetic interactions | K-4 | Dosimetric and exposure assessment |

The Dynamics of Coupled Oscillator Phase Control

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Arrays of coupled oscillators have been proposed as means of realizing high power rf sources **via** coherent spatial power combining.[1][2] In such applications, a uniform phase distribution over the aperture **is** usually desired. However, **it** has been shown that by detuning some of the oscillators away from the oscillation frequency of the ensemble of oscillators, one may achieve other useful aperture phase distributions. [3] Of particular interest among those achievable are **linear** phase distributions because these result in steering of the output rf beam away from the broadside direction. The theory describing the behavior of such arrays of coupled **oscillators is quite** complicated **since** the phenomena involved **are** inherently nonlinear. However, a simplified theory has been developed **which** facilitates **intuitive** understanding. [4] This simplified theory **is** based on a "continuum model" in which the aperture phase is represented by a continuous function of the aperture coordinates. A challenging aspect of the development of this theory **is** the derivation of appropriate **boundary** conditions at the edges or ends of the array.

We begin by reviewing the nonlinear equations describing the behavior of an array of loosely coupled oscillators. [2] The behavior of the phase of a single oscillator injection locked to an input signal,

$$V_{inj} = A_{inj} e^{j(\omega_{inj} t + \theta_{inj})} = A_{inj} e^{j\theta_{inj}} \quad (1)$$

can be described by the following differential equation.

$$\frac{d\theta}{dt} = \omega_o - \Delta\omega_{lock} \sin(\theta_{inj} - \theta) \quad (2)$$

where $\theta = \omega t + \phi$, ϕ is the phase of the oscillator oscillating at frequency, ω ,

$$\Delta\omega_{lock} = \frac{\omega_o}{2Q} \frac{A_{inj}}{A} \quad (3)$$

the locking bandwidth which is inversely proportional to the Q of the oscillator and A, the amplitude of the oscillation. For a linear array of N coupled oscillators, the **injection** signals are just the outputs of the other oscillators and the phase of the **i**th oscillator is described by a differential equation of the form,

$$\frac{d\theta_i}{dt} = \omega_o - \frac{\omega_i}{2Q} \sum_{j=1}^N \epsilon_{ij} \frac{A_j}{A} \sin(\theta_{ij} + \theta_i - \theta_j) \quad (4)$$

and $\epsilon_{ij}e^{j\Phi_{ij}}$ is the coupling between oscillators **i** and **j**. This system of equations, one equation for each value of i, has a coefficients matrix with zero determinant, a manifestation of the arbitrary nature of the phase reference. York has suggested that this may be remedied by dealing with phase differences between neighboring oscillators. Thus, we write,

$$\frac{d(\Delta\phi_i)}{dt} = (\omega_{tune,i+1} - \omega_{tune,i}) - \Delta\omega_{lock,ij} \sum_{\substack{j=i+1 \\ j=i-1}} (\Delta\phi_i - \Delta\phi_j) \quad (5)$$

where,

$$\Delta\phi_i = \phi_{i+1} - \phi_i \rightarrow \frac{\partial\phi}{\partial x} = \tilde{\psi} \quad (6)$$

the phase gradient. Consider an infinitely long linear array in which the center oscillator tuning frequency is increased by an amount C from the ensemble frequency at t=0. Limiting the coupling to nearest neighbors and taking the continuum limit (i becomes a continuous variable, x), results in,

$$\frac{\partial^2 \tilde{\psi}}{\partial x^2} - \frac{\partial \tilde{\psi}}{\partial \tau} = -\frac{1}{\Delta\omega_{lock}} \frac{\partial \omega_{tune}}{\partial x} = -Cu(\tau)\delta'(x) \quad (7)$$

where $\Delta\omega_{lock}$ is the mutual locking bandwidth of the coupled oscillators and includes the magnitude of the coupling constant, ϵ_{ij} , τ is time multiplied by the locking bandwidth, while $\omega_{tune}(x)$ gives the oscillator tuning frequencies. This equation may be solved via Laplace transformation with respect to time resulting in,

$$\phi(x, \tau) = C \left[2\sqrt{\frac{\tau}{\pi}} e^{-\frac{x^2}{4\tau}} - |x| \operatorname{erfc}\left(\frac{|x|}{2\sqrt{\tau}}\right) \right] u(\tau) \quad (8)$$

Note that this diverges as the square root of time as time approaches infinity. However, the frequency function, obtained by time differentiation, converges to the original ensemble frequency as one over the square root of time which is consistent with the fact that detuning one of the infinite number of oscillators does not change the ensemble frequency; i.e., the average of the tuning frequencies.

Consider now a finite length array extending from -a to a along x. The boundary conditions are derived by writing the equations of (5) for the oscillators at the ends of the array and proceeding to the continuum limit. This leads to,

$$\left. \frac{\partial \tilde{\psi}}{\partial \tau} \right|_{\left(a - \frac{1}{2}\right)} = \frac{1}{\Delta \omega_{lock}} \left. \frac{\partial \omega_{tune}}{\partial x} \right|_{\left(a - \frac{1}{2}\right)} + \left. \frac{\partial \tilde{\psi}}{\partial x} \right|_{(a-1)} \cdot \tilde{\psi} \Big|_{\left(a - \frac{1}{2}\right)} \quad (9)$$

$$\left. \frac{\partial \tilde{\psi}}{\partial \tau} \right|_{\left(a - \frac{1}{2}\right)} = \frac{1}{\Delta \omega_{lock}} \left. \frac{\partial \omega_{tune}}{\partial x} \right|_{\left(a - \frac{1}{2}\right)} \cdot \left. \frac{\partial \tilde{\psi}}{\partial x} \right|_{(a-1)} - \tilde{\psi} \Big|_{\left(a - \frac{1}{2}\right)} \quad (10)$$

solving (7) with these boundary conditions via Laplace transformation and integrating the resulting expression for the phase gradient gives the following for the transform of the aperture phase distribution.

$$f(x, s) = \frac{C}{2s^2} \left\{ \frac{(s+1) \cosh \left[\sqrt{s} \left(a - \frac{1}{2} - |x| \right) \right] + \sqrt{s} \sinh \left[\sqrt{s} (a-1 - |x|) \right]}{\cosh [\sqrt{s} (a-1)] + \frac{s+1}{\sqrt{s}} \sinh \left[\sqrt{s} \left(a - \frac{1}{2} \right) \right]} \right\} \quad (11)$$

This can be inverted via the calculus of residues in the form,

$$\phi(x, \tau) = \left[\frac{C\tau}{2a+1} + r_{-1} + \sum_{n=0}^{\infty} r_n e^{-\sigma_n \tau} \right] u(\tau) \quad (12)$$

where,

$$r_n = \frac{C}{2(2a+1)} \left[\frac{(2a+1)}{2} - |x| \right]^2 + K \quad (13)$$

indicating that the steady state frequency is shifted to the new average of the oscillator tuning frequencies and that the steady

state phase distribution is quadratic. Figure 1 shows typical space-time behavior of the aperture phase of a finite array obtained from (12).

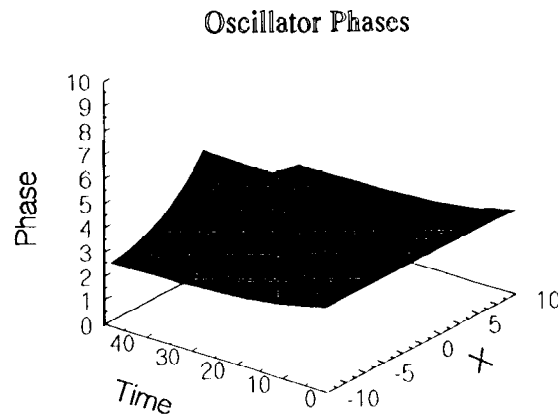


Figure 1. Typical space-time behavior of the phase of a finite length linear array of oscillators under step detuning of the center oscillator.

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4. R. J. Pogorzelski and R. A. York, "A Simplified Theory of Coupled Oscillator Phase Control," IEEE AP-S International Symposium, Montreal, Quebec, July 1997.